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SUBSTANCE OF A LECTURE

ON

THE APPLICATIONS OF CHEMISTRY

TO MEDICINE,

INTRODUCTORY TO A CHEMICAL COURSE

IN

THE NEWCASTLE MEDICAL SCHOOL.

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MEDICINE.

GENTLEMEN,—On this occasion I am induced to deviate somewhat from the ordinary routine of an introductory lecture, for reasons which may be briefly specified. Medical science appears about to undergo a great and beneficial change, from the use, by the medical inquirer, of those resources which an advanced state of the physical sciences places at his disposal, and from the diffusion of more philosophical notions than have long prevailed of the mode in which medical facts should be arranged and generalized. At the same time, many members of the profession seem not to be fully convinced of the value of the resources alluded to, nor to employ in practice such a mode of reasoning as should proceed from a clear conception of the logical constitution of Medicine.

The object of the present lecture is not to enter into a full explanation of this general subject, but to convince those who are to honour me with their attendance during the ensuing course, that by indulging a love of the beauty of truth, whilst in pursuit of the wonderful facts and lofty doctrines of a magnificent science, they are also qualifying themselves for the duties of the profession to which they have devoted themselves.

Before entering on the particular consideration of the topics announced, I deem it proper to make some general remarks, having reference to objections sometimes urged against the prac-

tical value of scientific studies. And lest any one should deem I am fighting with a mere shadow, the history of the introduction of the stethoscope may be referred to, and the prejudiced opposition which this useful discovery encountered from the mass of the professsiou. The same feeling which opposed the use of the stethoscope, now exists, to some extent, with regard to the application of Chemistry to Medicine; and he who devotes himself with zeal and ardent hopes to this new and promising investigation, receives from many that most damnatory title of *theorist*, which in some cases, when I have heard it applied, should have been translated into zealous and persevering, observing and talented—nay, I may venture to add, *practical*, in the true sense of the word. The meaning of these terms, theoretical and practical, as they are often used, is but the expression of a distinction which has existed between the philosophical and empirical practitioners of Medicine from the earliest periods, and is well stated in the pages of Celsus. This distinction arises naturally from the difficulties attending the practice of the healing ~~h~~art—the ignorance of all but its professors regarding it—which proceeds from the unpopularity of the preliminary studies of the medical man, and from the obscurity with which the results obtained in the treatment of disease are veiled from those most interested: from all these causes united, an extensive career is opened to every species of pretension. No profession requires such general attainments and extensive mental cultivation; and, consequently, when we consider the difficulties which beset the path of the conscientious and scientific practitioner, and the fatal ease with which the empiric may practise, we easily expect that no scrutiny can guard against the admittance into the medical profession of men inferior to its duties, and ever ready to maintain their position, by proclaiming loudly that empiricism is the only correct mode of pursuing medical truths, and that generalization, founded on analogy and the aids offered by science, is useless.

The distinction between the empirical and philosophical physician was much better marked in ancient times than at present;

and for this many reasons might be given. The threefold origin of Medicine in the Temples of Æsculapius, the Gymnasia, and the Academies, would necessarily cause some difference of view in the pursuit of the science among men differing in caste and educational bias. The physical sciences were for a long period incapable of affording material resources; and the earlier and slighter observations in Medicine are made with a comparative facility which does not attend the future progress of the science, but caused it to attain a certain degree of development, when the experimental sciences had scarcely an existence. This difference is founded, as shall afterwards be shown, on the principles of inductive logic; for we may compare the advance of the whole human race in knowledge to the progress of an individual, and account for the various phases of the cultivation of science from the study of the process which the mind is compelled to adopt in generalizing its sensations.

But, even in the infancy of the art, we find the Father of Medicine uniting the science and the practice of his day; and the treatise on the influence of air and locality furnishes sufficient proof of his desire to avail himself of such resources as science could then afford.

And with regard to theory and practice it may be observed, that nothing is less practical than a mere fact which can include nothing and relate to nothing, until the mind has worked on it, and associated it according to the laws of mental assimilation. Those sciences which are the most abstract are in reality the most practical, being the highest generalizations, and therefore including most within their grasp; and to talk of that being false in practice which is true in theory, is to assert that our Maker has deceived us, and taught us to form false conclusions, through the legitimate workings of the intellect. Let us then make sure of our footing, but endeavour to climb the loftiest pinnacles of science, that we may feast our view with the illimitable prospect below.

Before concluding this lecture, I trust to exhibit sufficient proof of the value of chemical research in the strictly practical departments of Medicine. Chemistry may be said to afford assistance to Medicine directly, by the light it throws on the theory of disease and on treatment, and by the many valuable remedies which it has furnished; and indirectly, by the illustrations it lends to Physiology (the basis of Pathology), and by its numerous applications in Forensic Medicine and in Hygiene.

After treating the subject under these heads, (the order of which I shall however slightly alter,) I shall make some remarks on the logical place of such resources as the physical sciences afford in the elevation of the general laws of Medicine.

First, then, of the applications of Chemistry to Physiology. We may regard the organized being as an entity which effects changes on foreign matters, fitting them to become part of its structure, and removes such parts of the structure as are unfit for the purposes of life. We have a force which attracts matter around it, and performs such changes on this matter as are required for the existence and development of the force in a certain form. These changes, both of incrementition and excrementition, are, for the most part, essentially chemical: we must state them in the language of Chemistry, as we arrive at a knowledge of their nature chiefly by chemical analysis. It is true that we cannot explain how these changes are effected by the vital principle. We can only say that they are produced by vital affinities, in the same way as we speak of the chemical action exerted by the rays of light, by heat, or by electricity. The nature of the ultimate force cannot intervene in our explanations of physiological laws, any more than the truth of the law of gravity is dependent on the knowledge of the cause of attraction.

The physiology of digestion may be taken as an illustration of the wide scope of chemical reasoning in explaining the functions of the body. The mode in which we explain the presence of chlorine in the gastric juice, and also the action of this fluid,

yields a case in point. Chloride of sodium, introduced from without, is decomposed in the stomach by a species of electro-vital affinity—the stomach forming as it were the positive, and the liver the negative, poles of the battery. Thus the necessary condition of acidity of the food during chymification is secured; and as the soda of the decomposed salt is eliminated with the bile, this acidity, unnecessary during chylification, is corrected in the duodenum. Then follow chemical explanations of the reducing and converting operations of the digestive organs on the principles of the food—of the completing processes carried on in the lungs, and at the extremity of the circulation—of the change of arterial into venous blood, by the conversion of the albuminous principle of the blood into the gelatin of the cutaneous envelope—of the evolution and maintenance of animal heat—of the various processes of secondary assimilation, by which the effete portions of the tissues are removed—of the extrication of carbon by the lungs and liver, and of nitrogen by the kidneys—the conversion of gelatin into urea, and of albumen into lithic acid—in one word, of all the alterations which take place during secretion and excretion, as far as they have been explored.

Secondly, of the application of Chemistry to Pathology and Therapeutics. The early cultivators of Chemistry were mostly medical men, and made many attempts to explain the phenomena of disease by means of their favourite science. But their efforts were for the most part premature, and only brought discredit on the legitimate use of chemical reasoning. The human mind appears subject to something like the mechanical law of action and reaction; and the extravagant and fantastic hypotheses of Paracelsus, Van Helmont, and Sylvius, after a transitory reign, only left behind them that sensation of disappointment and disgust which attends expectation unfulfilled, after being raised to the highest pitch.

The Humoral Pathology, whose history has, in modern times, been intimately connected with Medical Chemistry, had a similar sway, and again fell into too great neglect at a period when

Morbid Anatomy began to be cultivated with the zeal and industry by which such valuable results as those we now possess have been obtained. At length it came to be observed that the changes of which ordinary Morbid Anatomy is cognizant, are only secondary to alterations in the fluids, which constitute so large a portion of the system, and are more interested in the commencement of diseased actions.

Now the alterations of the fluids require to be investigated by the microscope, and especially by chemical analysis. Compared with the results likely to be obtained by these potent instruments of research, what has hitherto been accomplished by Pathology may prove insignificant, although valuable at present as the basis of more important investigations. In approaching the real nature of disease, the ordinary (perhaps we might say the old) Morbid Anatomy must appear as mere picture-making beside the kind of research of which we have a model in the work of Dr. Prout. And at a future period, when Medical Chemistry shall have produced results of which at present we have but little conception, this immortal work shall remain like some ancient and venerable pillar in the midst of a flourishing metropolis, an eternal monument of its author's glory.

Hufeland, in his work on scrofula, has forcibly pointed out the importance of a pathology of the fluids. "I cannot sufficiently repeat, that, to judge adequately the state of a system of organs, we must take into consideration the system itself, and the fluids which it holds in circulation—for the influence is reciprocal." He proceeds to remark, "The fluids are the natural stimulus of the vessels; or, in other terms, the vessels only enter into action by the irritation exercised on them by the fluids. This is a law of nature. Nevertheless, we hear but of the irritability of these vessels as the cause of their movements." Again, "The humours are the natural stimulus of the solids, the moving force of their functions; which proves, let us state in passing, that the fluids should be considered in a pathological system."

I lay so much stress on the importance of a consideration of the diseased states of the fluids, because it seems scarcely possible to discover them, except by chemical analysis; which, however, is equally applicable to the study of the alterations of the solids of the body from their healthy state.

Of late, the researches of Bright, Prout, Christison, Rayer, Willis, Becquerel, Golding Bird, and Andral, have contributed to found a true Chemical Pathology, of which a few illustrations may be given.

Andral has discovered that the prominent principles of the blood vary in disease extensively from the healthy standard of proportion, and that these variations characterize four great classes of diseases; and although his analyses be but superficial, still they show the value of this kind of investigation, since, without regard to any other nosological arrangement, they have led him to found certain genera having much the characters of natural families. Thus the phlegmasiæ are characterized by excess of fibrin in the blood, and the same condition prevails in the latter stage of phthisis; the pyrexiæ by general diminution of the fibrin and increase of the globules, which state bears a ratio to the amount of existing depression of the powers of the system. The same circumstances have been observed in the cerebral congestions and hæmorrhages. In chlorosis we find the type of a class of diseases, in which the globules are diminished in quantity, but the proportion of fibrin little affected. Or the alteration of the blood may be of quite a different character, and the organic matters of the serum may be removed, as in Bright's disease of the kidney.

The value of Medical Chemistry is strikingly exemplified in the investigation of kidney and urinary disease. The kidney is one of the most important organs of excrementition. Any considerable deviation from its healthy texture is speedily followed by serious or fatal consequences. This organ, as Dr. Willis remarks, is found very far down the scale of the animal creation;

since even in insects we find organs which appear to excrete nitrogen, and frequently contain calculi of uric acid. In fact, the healthy state of the kidney appears scarcely less essential than that of the lung to the maintenance of animal life. The food of animals may be regarded as finally decomposed, by the action of the organism, into carbonic acid and urea—the former excreted by the lung, and the latter by the kidney.

The most important diseases of the kidney are manifested by changes in the character of the urinary secretion, which for the most part must be detected by chemical analysis. Either the healthy ingredients of this fluid vary in their proportion from the healthy standard, or some of them are removed, and frequently foreign matters are substituted. The most important points in the pathology of Bright's disease have been elucidated by the use of the resources which Chemistry furnishes. Thus we are enabled to discover that in this disease the nutritious principles of the blood are allowed to escape by the kidney, while this organ does not separate that excrementitious principle and those salts which in the healthy state its chief office is to remove. Thus the deprivation undergone by the blood, and the introduction of a poisonous principle into this vital fluid, are the indices of the phenomena of that Protean disease. Cases are continually occurring, where, without some knowledge of chemical manipulation, the practioner must be continually at fault in the diagnosis of Bright's disease. Such are the intermixture of coagulable urine with pus and mucus from an ulcerated bladder, or the existence of a large portion of phosphatic salts in the urine. Diabetes is another disease in which chemical analysis has been of great service. In particular, the detection of sugar in the blood of diabetic patients has given us a clearer insight into the real nature of this affection, proving that it is not to be attributed to the kidney, but to malassimilation, either in the processes of primary or secondary digestion.

The study of calculous affections, and the connexion between them and disorders of digestion, so admirably treated by Dr.

Prout, furnish us with innumerable instances of the applications of Chemistry; and being unwilling to accumulate illustration, I shall conclude, under this head, by quoting the words of this author in the preface to his last edition, where he states that he "invites the candid criticism of the experienced chemical pathologist, who is alone capable of appreciating his labours."

When we turn our attention to what Chemistry has done for the treatment of disease, and then consider what may be accomplished through the resources of this ever-progressing science, we are astonished by the vastness of the subject. Chemistry is here useful by the discovery of new remedies, by the rules which it frequently furnishes for the administration of remedies, by the view which it affords us of their medicinal action, and by the precautions which it enforces for their combination. Even in the days of Paracelsus, Chemistry here shone supreme; and it was by the employment of those remedies with which his chemical art furnished him, that this extraordinary being was enabled to overturn the then existing superstitious veneration for the ancient authors. In the words of the learned Morhof, (which, on the ground stated, are alone applicable)—"Magna tamen in ipso mentis vis fuit, magna arcanorum naturæ cognitio, quo factum est ut medicinam in novam aliquam speciem transfunderet. Gloriari tamen Germani hoc nomine possunt. Hujus enim artibus, pene tota schola medicorum Galenica de sua dejecta est dignitate. Quod viro illi contigisset in juventute literarum cultura, quibus ornasset suam doctrinam non majus habuisset Germania nomen."

As instances of the benefit which the progress of Chemistry has conferred on Medicine, merely by the discovery of new remedies, nearly every article in the Materia Medica might be adduced. Look at the benefit we derive from the recently-invented processes by which the active principles of so many drugs are separated from others absolutely obstructive of our wished-for aim, and by which we can retain those active principles of uniform strength in forms incapable of alteration by keeping. The dis-

covery of iodine is a case in point too brilliant to be overlooked. This remedy had been administered in the form of burnt sponge, according to my learned friend Dr. Cogswell, from the time of Arnold of Villanova in the thirteenth century. And as the drug was prepared on no uniform plan, since no one knew the rationale of its action, nor the nature of its active principle, an infinity of opinions prevailed with regard to its merits. Nay, this *questio vexata* was not finally settled, until the discovery of iodine in sea plants led Coindet to conjecture that the virtues of burnt sponge might depend on the newly-discovered principle. How felicitous this conjecture proved! Here we are presented as it were with the spectacle of one groping his way in the dark hesitatingly and with dread, on whose hitherto obscured path a flood of light is at once directed.

It is with great pleasure that I refer to a recent discovery of Mr. Alexander Ure, as affording an instance of the successful treatment of a disease on purely chemical principles. The effect of the mutual action of the benzoic and uric acids is to produce the urobenzoic or hippuric acid, whose salts are very soluble compared with those of uric acid. On this fact Mr. Ure proposed to administer benzoic acid to gouty patients, with the view of changing the insoluble urates of gout-stones into soluble hippurates, and thus procuring their removal from the body. And this proposal has been successfully carried into effect both in this country and in France. Equally chemical is the treatment of many forms of deranged digestion, and of diabetes; and by the operation of remedies administered on chemical principles, the use of the knife, that *ultima ratio medicorum*, is frequently precluded in calculous disorders.

I pass over the other points of view indicated, in which we may regard the applications of Chemistry to Therapeutics, and proceed to the *third* division of the subject—Forensic Medicine and Hygiene. Here the applications in question are so numerous and so obvious, that I shall only refer to them generally, without giving any detailed illustrations.

By Chemistry we are taught to comprehend the destructive agency of corrosive poisons, and to estimate the amount of mechanical injury which they are capable of inflicting on the tissues—to detect deleterious agents in the blood and organs, and thus to determine the parts to which they are chiefly directed, and the functions which they are most materially calculated to affect. By the same means, it may be observed, the therapeutic action of remedies is better understood; for the toxicological study of an agent is but that of its remedial agency exaggerated, and manifested on a hitherto healthy organ. Thus, in one point of view, Toxicology may be said to stand in a similar position to Therapeutics, as that which Physiology itself maintains in regard to Pathological science.

By means of the aids which Chemistry offers, is the medical jurist often enabled to convict the guilty, or enjoy the supreme satisfaction of succouring the innocent and oppressed, and allowing the poor victim of popular calumny to recover his liberty, and to preserve his life, to vindicate his fame, and to avert ignominy from his memory. Never does the native dignity of our profession soar higher than when we realize those awful or beneficent privileges. Then the ignorant scoffer is made to reverence the supremacy of science, and the worldling to admit that knowledge is power. For we have reason indeed to be proud of the position which our profession occupies in facilitating or rightly directing public justice; and we should all strive with our utmost energies to maintain the ground we have thus gained, nor to bring disgrace by any inadequacy of ours on the lofty claims of science. And here nothing short of an extensive acquaintance and familiarity with chemical research is available. The evidence of Orfila proved the existence of arsenic in the body of Laffarge, after less-experienced chemists failed to detect its presence. There is a general impression in this country, that the testimony of Orfila has been shaken by subsequent researches. But there can be no doubt of the truth of the conclusions arrived at on that occasion by this great toxicologist. The recent Reports of the Academy of Medicine and the Institute, on arsenical

testing, differ on minor points, but agree that a practised chemist cannot fail to detect the difference between the stains which Marsh's apparatus yields with arsenic, and those which are obtained through it with organic substances.

In the doctrine of miasms and contagions, in the detection of deleterious effluvia and their destruction, Chemistry is not less applicable. Witness the concluding chapter of Professor Liebig's work, translated by my friend Dr. Playfair; and the recent paper of Dr. Daniell on the extrication of sulphuretted hydrogen on the coast of Africa, by the action of organic matter on the water of the ocean.

The subject of mineral waters offers a beautiful field to the medical chemist; but it is so well known, even to those unconnected with the medical profession, that chemical analysis is required to ascertain the constitution and therapeutic characters of the various species, that I do not think it necessary to dwell on this application of Chemistry.

Fourthly, I arrive at a subject which appears to me of great importance, but which I shall not be able to discuss in a commensurate degree in this lecture—I mean the consideration of the logical place which the resources offered by the physical sciences occupy in the elevation of the general laws of Medicine. The whole connexion of this question with the recently-proposed applications of statistics and the doctrine of probabilities to Medicine should be stated. At present I must endeavour to arrive at the point aimed at in a few prominent observations.

We have, first, two classes of sciences—those which are abstract, and those of fact.

In the latter class, the mind is constantly striving to overcome the obstacles which its imperfect media of communication with the external world interpose, and to obtain the same control over Physics that it has over the purely abstract notions out of

which it eliminates the propositions of the abstract sciences. To do this, it endeavours to reach the ideas of power, causation, and connexion between facts observed to accompany one another, which are excited in it by the observed relation of the facts, but which, nevertheless, exist in it alone, and cannot be discovered to have anything like them in the external world. These ideas of relation, power, and force, are exactly the ideas which, according to Locke, owe their birth to internal sensation; and could the mind obtain them by induction, its control over Physics would be as complete as that which it exerts in the abstract sciences.

As an example:—We see a spark fire gunpowder. We inquire why; and we make this inquiry because we are compelled to believe in an adaptation of the spark to bring about the deflagration. But neither in our early nor subsequent investigations, however far we push the inquiry, can we detect this adaptation; but the search after the *cause* produces a series of physical laws.

Now, an experiment is an attempt to establish a relation between two or more properties—*i. e.*, to ascertain whether an apparent relationship be irregular or non-essential, or constant and essential, dependent on the very nature of the properties:—and this, whether the properties are to one another as antecedent and consequent, or merely exist simultaneously.

Now, by an experiment, the labour of induction is materially abridged; since, having found a genus of instances to contain a property *a*, and this to be connected in a manner which we are compelled to believe essential in some instances of the genus with *b*, we assert that the two properties exist connected throughout the whole genus.

In order to place the properties in such lights as to enable us to judge of the essentiality or non-essentiality of their relationship, we frequently require the use of instruments.

We term that observation as distinguished from experiment, where the instances do not admit of being investigated prerogatively, and where every instance of a genus must be examined before a general conclusion can be arrived at.

The logical difference between Medicine and the Physical Sciences, whether of observation or experiment, may be stated to consist in this—That in Medicine we cannot form the preliminary genus required for the explication of prerogative reasoning; neither can we frame a true and strict general law by any labour. For every human being differs from another in respect of the character required in our inductions. And new (*i. e.* different) instances are continually occurring. We know, by experience, that a remedy will cause different effects, and a morbid lesion occasion different symptoms in different members of the human race. So that we are obliged to travel from instance to instance, founding our application to one, of what has been observed of another, on an assumption of probability. Hence, some have proposed to apply the calculus of probabilities to the generalization of medical facts. Be it observed, that we are not the less bound to carry out our generalizations into practice, because they are founded on this assumption of probability. The general laws of Medicine are as binding on us in practice, as those of Physics; because, if they are rightly framed, we have made every allowance that the case admits of. Now the application of the resources of the Physical Sciences does not enable us to overcome this fundamental difficulty, but it better fits the instances for entering into our calculations.

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